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None

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(54) **Cutting tools**

(57) A device for the fine machining of bores such as a reamer or a cutter tip 31 has a cutting edge which is divided into a main cutting edge and a secondary cutting edge 54. Embedded in the parent body 32 is an insert 33 which consists of a carbide backing 43 and a crystalline structure 48 of great hardness, such as polycrystalline diamond PCD or cubic boron nitride CBN, sintered on the carbide backing 43. A transition zone 52 is located in between. The insert 33 is arranged in such a way that the secondary cutting edge 54 is formed in successive sections by the very hard crystalline structure 48, the less hard transition zone 52, the even less hard carbide backing 43, and finally the relatively soft carbide of the parent body 32. The drilling device has a substantially prolonged service life and enables bores having a very good surface quality to be produced.

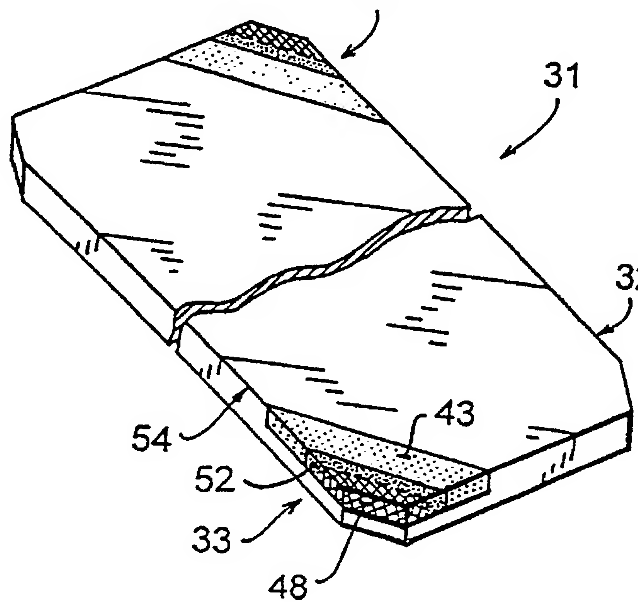

Fig.1

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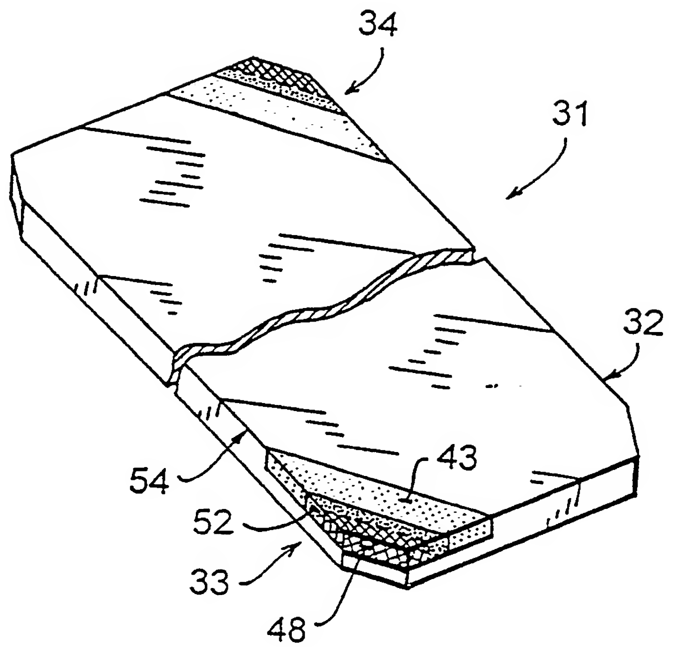
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Fig.1

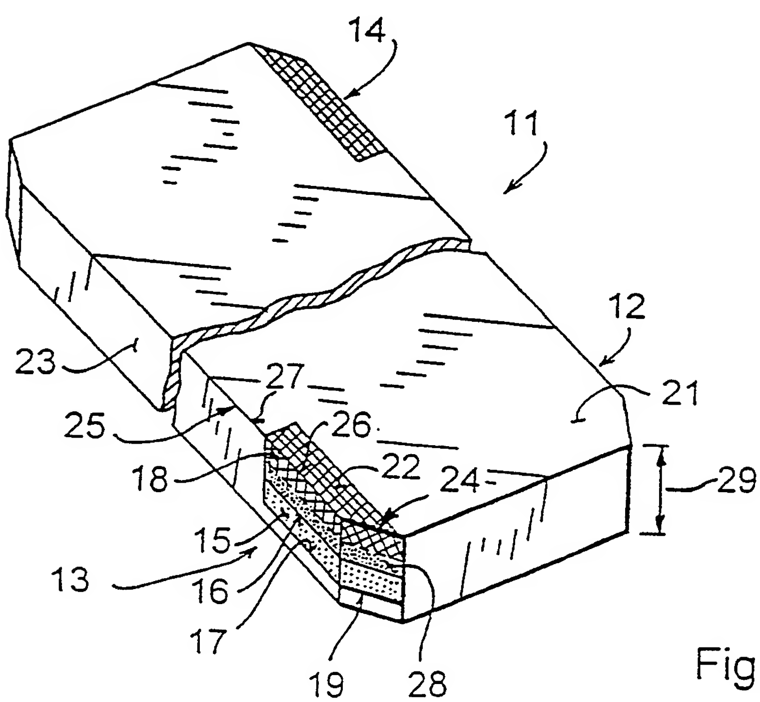
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Fig.2

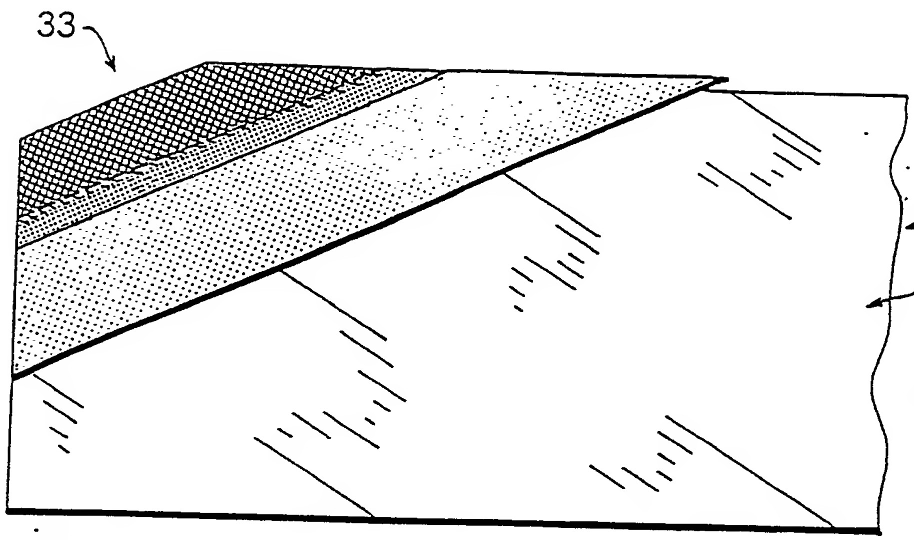

Fig.3

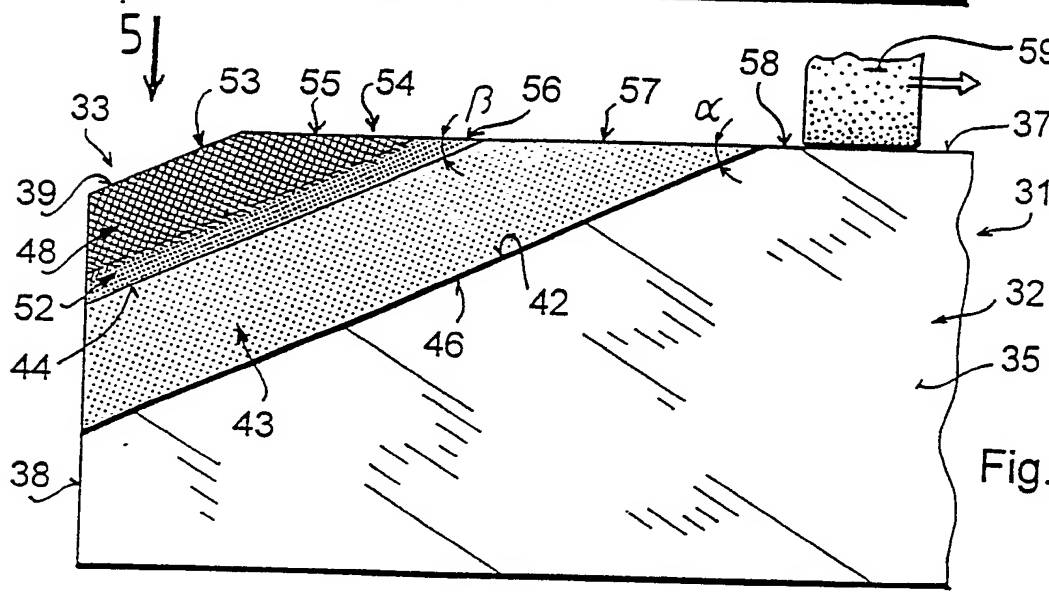

Fig.4

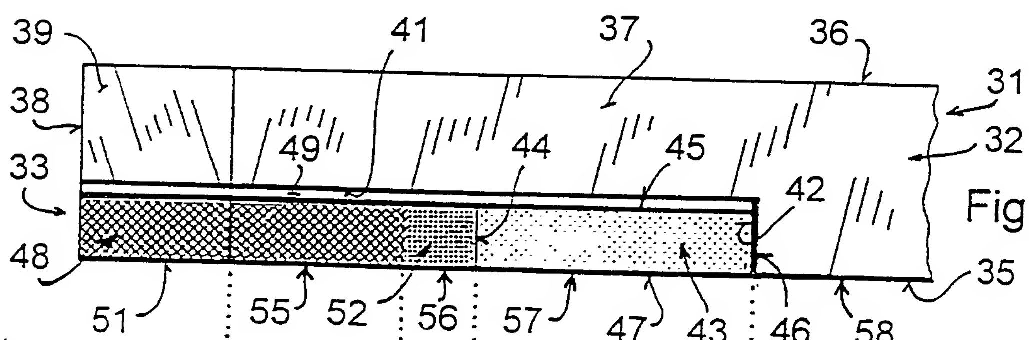

Fig.5

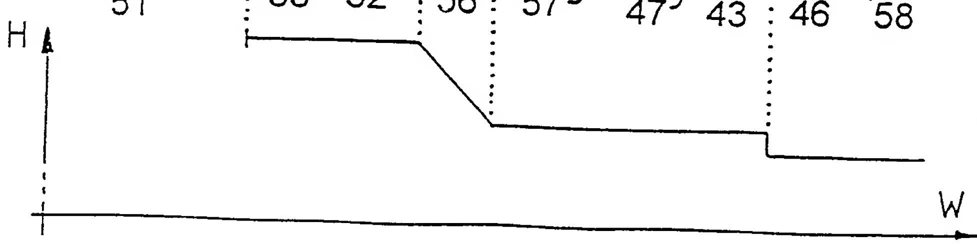

Fig.6

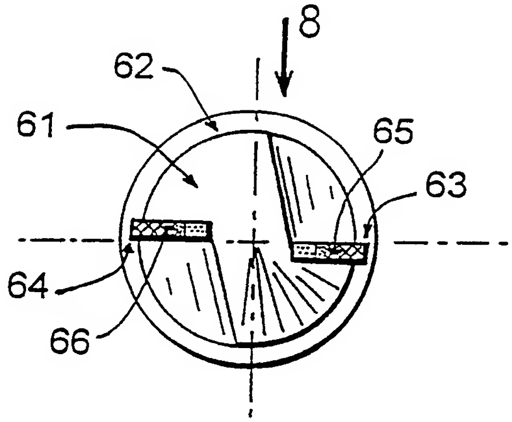

Fig.7

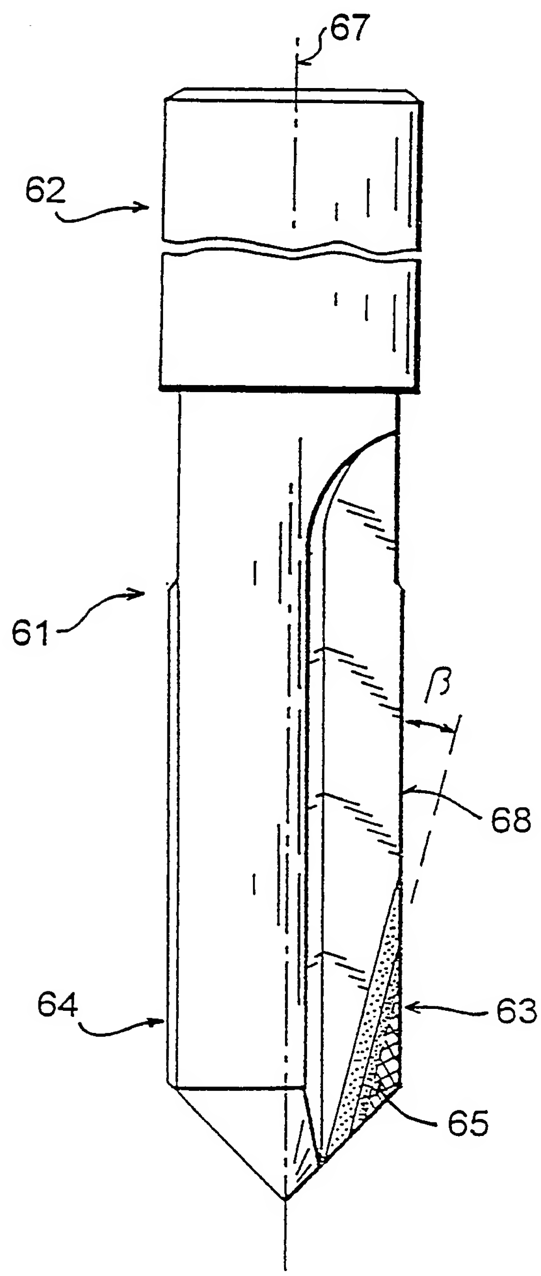

Fig.8

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CUTTING TOOLS

The invention relates to cutting tools and particularly, but not exclusively to cutting tools for use in fine machining bores.

A typical device for the fine machining of bores is a reamer, for example of a similar type of construction as described in GB 571394 or of the type described in principle in German Auslegeschrift 1144568. But a drill according to German Auslegeschrift 2502183 is also regarded as a device of this type. Characteristic thereof is the fact that each secondary cutting edge guides the tool in the bore, either together with the secondary cutting edges of further cutting edges distributed over the periphery of the drilling head or as an addition to special guide strips. The secondary cutting edges with their supporting and smoothing functions are also decisive for the quality of the bore. Great importance is therefore attributed to the straightness of the secondary cutting edge. The secondary cutting edge is normally ground as straight as possible in the longitudinal direction, the desired sharpness of the secondary cutting edge also being produced at the same time.

In so far as the cutting edge is formed on a one-piece parent body, for example a drilling head of high-speed steel or a cutter tip of carbide, the grinding poses no problems. Recently, however, there has been a change-over to the practice of attaching an insert to the parent body, which insert consists of a carbide backing and a hard crystalline material of great hardness which is sintered on the carbide backing and forms the main cutting edge and an adjoining part of the secondary cutting edge. For cost reasons, the extension of the hard crystalline material is restricted to a section of the secondary cutting edge. In this arrangement, the sandwich-like insert is attached in such a way that the first plane is parallel to the second plane. During the grinding, the grinding wheel is moved along the secondary cutting edge and in the process works first of all against the very hard crystalline material. Stresses therefore build up in the mechanical grinding system

which are released suddenly as soon as the grinding wheel leaves the zone of the hard crystalline material and then strikes the softer parent body. As viewed in the microscale, therefore, the straight line is given the configuration of a mountain landscape. The difference in height between the highest and the lowest point is called the "bandwidth of the straight line". Even when the grinding operation is carried out carefully a bandwidth of less than 5 µm cannot be reached. This therefore limits the bore quality which can be produced with this cutting edge.

The object of the invention is to create a device of the type as defined in the preamble which enables better bore qualities to be achieved.

This object is achieved by the characterizing features of Claim 1.

The insert is now laid as it were on its side so that not only does the hard crystalline material reach the secondary cutting edge but so too does the carbide backing and the transition zone between hard crystalline material and carbide backing. Accordingly, the secondary cutting edge is preferably formed by at least three materials according to Claim 2 which have a different hardness. When the grinding wheel is now moved over the secondary cutting edge, it works in turn first of all against the very hard crystalline material, then against the slightly less hard area of the transition zone, and finally against the even less hard area of the carbide backing. Thus the mechanical stresses in the grinding system can be released gradually. Owing to the fact that the first plane is orientated at a small angle to the secondary cutting edge, an extension of the section of the secondary cutting edge formed by the transition zone and thus a further reduction in the hardness increment along the secondary cutting edge result.

In the refinements according to Claims 3 and 4, an additional hardness graduation is obtained, in which case it can be assumed that the hardness of the parent body is in turn less than the hardness of the carbide

backing.

Claims 5 and 6 specify materials which can preferably be used as the hard crystalline material. Here, polycrystalline diamond PCD has the advantage of the greatest hardness presently available, whereas cubic boron nitride CBN, although less hard, is instead chemically more stable when drilling in steel and therefore makes possible a longer service life of the drilling device.

Angular ranges according to Claim 7 result in a good length of the section of the secondary cutting edge formed by the transition zone and also in support of the hard crystalline material relative to radial and axial drilling-force components, which support helps stability.

In the refinement according to Claim 8, the cutting edge is formed on a cutter tip of carbide so that the drilling head can be made of a less expensive material which is also less sensitive to blows.

In the refinement according to Claim 9, the entire fine-drilling head is formed from a cutting material such as high-speed steel or carbide, and a section of the secondary cutting edge is directly formed by a part of the drilling head. Another section directly carries the insert having the hard crystalline material. This type of construction is convenient for very small bore diameters.

Further advantageous refinements and developments of the invention follow from the description below of exemplary embodiments shown in the drawing, in which:

Fig. 1 shows a cutter tip according to the invention in perspective representation,

Fig. 2 shows a cutter tip according to the prior art in perspective representation,

Fig. 3 shows a plan view of a corner area of the cutter tip from Fig. 1 in the state before the grinding treatment,

Fig. 4 shows a representation corresponding to Fig. 3 in the state after the grinding treatment,

Fig. 5 shows a side view in arrow direction 5 of Fig. 4,

Fig. 6 shows a diagram which shows the pattern of the hardness appearing along the secondary cutting edge,

Fig. 7 shows a front view of a reamer according to the invention,

Fig. 8 shows a side view in arrow direction 8 of Fig. 7.

A known cutter tip 11 according to Fig. 2 consists of a rectangular, flat parent body 12 of carbide. The corners are bevelled, and one insert 13, 14 each is arranged in a niche-shaped recess at two diagonally opposite corners. Both inserts are identical and therefore only the insert 13 will be described in more detail below. This insert 13 consists of a carbide backing 15, which has a first plane 16 pointing upwards and a bottom second plane 17 orientated parallel thereto, and also of a hard crystalline material 18, for example of polycrystalline diamond PCD, sintered on the first plane 16. With its second plane 17, the carbide backing 15 is brazed in a fully seated manner to a bearing plane 19 which runs parallel to the top side 21 of the parent body 12. The top side 22 of the hard crystalline material 18 is flush with the top side 21 of the parent body 12. In a conventional manner, the edge area between a rake face in alignment with the top side 21 and a flank in alignment with the peripheral surface 23 of the parent body 12 forms a cutting edge. The latter is subdivided into a main cutting edge 24 and a secondary cutting edge 25. The top outer edge of the hard crystalline material 18 completely forms the main cutting edge 24 and an adjoining section 26 of the secondary cutting edge 25. Following the adjoining section 26 in rectilinear extension is a section 27 which is directly formed by the top outer edge of the parent body 12. During the sintering operation, a transition zone 28 develops between the carbide backing 15 and the hard crystalline material 18, namely owing to the fact that molecules of the hard crystalline material 18 penetrate slightly into the matrix of the carbide. This transition zone 28 has no special significance in this arrangement. Fig. 2 shows

the ground final state of the cutter tip 11. In order to achieve this, a rotating grinding wheel is moved along the secondary cutting edge 25. In the process, the grinding wheel first of all grinds the very hard section 26. Compressive stresses consequently build up in the mechanical system of the set-up of the cutter tip and the mounting of the grinding wheel, which compressive stresses are released suddenly as soon as the grinding wheel reaches the section 27, which is substantially less hard. This release of the compressive stresses can be accompanied by overshooting of the mutually movable parts of the grinding system. In effect, the secondary cutting edge 25 does not run in an ideal straight line in its sections 26 and 27; on the contrary, the bandwidth of the straight line is above 5 µm. Fig. 2 shows that, as a result of the vertical sequence of carbide backing 15, transition zone 28 and hard crystalline material 18, a minimum thickness 29 of the cutter tip 11 results, below which the thickness cannot fall.

In contrast, the cutter tip 31 shown in Fig. 1 is considerably thinner. Its outline corresponds to that of the cutter tip 11. One insert 33, 34 each is arranged in a niche-shaped recess at two diagonally opposite corners of the parent body 32 of carbide in a manner which will be described in greater detail with reference to the enlarged representations of Figs. 3 to 5, taking insert 33 as a typical example. It goes without saying that a cutter tip can also have only a single insert 33.

The parent body 32 of the cutter tip 31 has a plane top side 35 and a plane underside 36 parallel thereto, a longer peripheral surface 37 and a shorter peripheral surface 38 perpendicular thereto, a sloping peripheral surface 39 being formed in between. Extending across this corner area, a niche-like recess is formed in the parent body 32, which niche-like recess constitutes a bearing plane 41 orientated parallel to the top side 35 and having a trapezoidal outline. In this arrangement, the outline edge of the bearing plane 41 follows the full length of the sloping peripheral surface 39 and in each

case part of the length of the peripheral surfaces 37, 38 adjoining on either side. Located roughly parallel to the outline edge running along the sloping peripheral surface 39 is a step surface 42 which is orientated perpendicularly to the bearing plane 41 and at a small angle α to the longer peripheral surface 37.

The insert 33 first of all consists of a carbide backing 43, the first plane 44 of which is orientated perpendicularly to bearing plane 41 and thus also perpendicularly to its second plane 45 as well as at a small angle β to the longer peripheral surface 37. The carbide backing 43 has a third plane 46 which is preferably orientated parallel to the first plane 44 and is supported on the step surface 42. In this case, $\alpha = \beta$. A fourth plane 47 extends in parallel opposite the second plane 45, which fourth plane 47 is in alignment with the top side 35 in the finished final state.

Furthermore, the insert 33 is made of a hard crystalline material 48 which can consist of cubic boron nitride (CBN) or polycrystalline diamond (PCD). This hard crystalline material 48 has been sintered onto the first plane 44 before the insert 33 is brazed with a thin brazing layer 49 to the bearing plane 41. The hard crystalline material 48 closes the niche-shaped recess; that is, it has a top side 51 which is in alignment with the top side 35. The transition zone forming during the sintering operation is identified by the reference numeral 52.

In the final state according to Fig. 4, a cutting edge which is divided into a main cutting edge 53 and a secondary cutting edge 54 is obtained at the outline edge of the cutter tip 31. Here, the main cutting edge 53 is completely formed by the outer edge of the hard crystalline material 48. The secondary cutting edge 54, however, is formed by a plurality of sections of different hardness, specifically by a first section 55 formed by the hard crystalline material 48, a second section 56 formed by the transition zone 52, a third section 57 formed by the carbide backing 43, and a fourth section 58 formed by

the material of the parent body 32.

Since the insert 33 cannot be produced to the required dimensional accuracy, it is produced according to Fig. 3 with slight oversize and is brazed into the recess of the parent body 32. As a result, the main cutting edge 53 can be finish-ground, and the top sides 35, 51 and the fourth plane 47 can likewise be ground flat. In particular, the secondary cutting edge 54 is ground by a grinding wheel 59 indicated in Fig. 4 being guided along the secondary cutting edge in the longitudinal direction.

To this end, Fig. 6 illustrates the pattern of the hardness H along the path W, as presented in principle to the grinding wheel 59. Thus the full hardness of the hard crystalline material 48 opposes the grinding wheel 59 during the grinding of the first section 55. During the grinding of the second section 56, a hardness pattern dropping down to the hardness of the carbide backing 43 appears, as a result of which an abrupt transition is avoided. Then the lower hardness of the carbide backing 43 takes effect during the grinding of the third section 57, and finally the still lower hardness of the parent body 32 takes effect during the grinding of the fourth section 58. In this multi-stepped hardness pattern, stresses in the mechanical grinding system are not released suddenly, so that a bandwidth of the straight line of the secondary cutting edge 54 of less than 5 µm, in particular in the region of 1 µm, can be achieved.

The lengths of the sections of the secondary cutting edge 54 in the case of a cutter tip tested in practice are, for example, as follows: first section = 1.3 mm, second plus third section = 1.7 mm, at $\beta = 30°$. It can be seen from this that very small inserts are used in order to strengthen only the areas of the cutting edge which are subjected to the greatest loading. The representations in Figs. 1 to 6 are not true-to-scale but are only to be understood in principle. The main cutting edge 53 can also be of angled configuration, which is not

shown. It goes without saying that the rake face (top side) can enclose an angle of less than 90° with the flank (peripheral surface). The general form of cutting edges and in particular of cutter tips is known per se and these known configurations are therefore not specially shown.

Figs. 7 and 8 illustrate an embodiment of a two-edged reamer whose drilling head 61 together with clamping shank 62 is produced from cutting material such as, for example, carbide. Here, the drilling head 61 takes the place of the plate-shaped parent body 32 in Fig. 1. Accordingly, inserts 65 and 66 of the same type in principle as the insert 33 are fitted into the cutting-edge areas 63 and 64. Fig. 8, for the secondary cutting edge 68, which is parallel to the drill axis 67 or if necessary is slightly tapered, shows that this secondary cutting edge 68 is likewise formed by a plurality of successive sections of different hardness. The angle ß is 15° here, as a result of which the sections extend over a larger axial length. Since no separate cutter tips are used, this reamer is also suitable for very small bore diameters, namely diameters of less than 6 mm, preferably less than 5 mm. In a similar manner, four-edged reamers can also be formed.

The comparison between Figs. 1 and 2 shows on the one hand the different composition of the secondary cutting edges 25 and 54 and on the other hand the different thickness of the cutter tips 11 and 31. The thickness of the cutter tip 11 is determined by the vertical (in the view according to Fig. 2) layer sequence of the insert 13, in which case the carbide backing 15 has to have a minimum thickness, below which the thickness cannot fall, so that the carbide backing 15 can withstand the stresses when the hard crystalline material 18 is being sintered in place. The hard crystalline material 18 in turn can only be produced in a minimum thickness of about 0.5 to 0.8 mm on the first plane. As a result of the horizontal layer sequence according to Fig. 1, the "minimum heights" applicable to the production of the

insert 33 can be accommodated in the tip plane, which provides a sufficiently large space for this purpose. The minimum thickness, now to be regarded in the vertical direction, of the insert 33 is around 0.2 mm and is determined solely by the stability of the insert.

The angle ß can have values of 10° to 50°, flatter ranges between 15° and 30° being the most convenient.

CLAIMS:

1. Device for the fine machining of bores, comprising at least one cutting edge between a rake face and a flank, which cutting edge is subdivided into a main cutting edge and a rectilinear secondary cutting edge and is formed on a parent body and an insert, which insert consists of a carbide backing and a hard crystalline material, the hard crystalline material being sintered on a first plane of the carbide backing, and a second plane of the carbide backing, which second plane is orientated at least approximately parallel to the rake face, being provided for fastening to a bearing plane of the parent body, which hard crystalline material forms the main cutting edge and an adjoining part of the secondary cutting edge, characterized in that the first plane (44) is orientated at least approximately perpendicularly to the second plane (45) and at a small angle (ß) to the secondary cutting edge (54).

2. Device according to Claim 1, characterized in that the secondary cutting edge (54) is formed from at least the following, successive sections:

a) a first section (55) formed by the hard crystalline material (48),

b) a second section (56) formed by the transition zone (52) between hard crystalline material (48) and carbide backing (43),

c) a third section (57) formed by the carbide backing (43).

3. Device according to Claim 1, characterized in that the parent body (32, 61) is made of a cutting material.

4. Device according to Claims 2 and 3, characterized in that the secondary cutting edge (54), adjoining the third section (57), has a fourth section (58) which is formed by the parent body (32, 61).

5. Device according to Claim 1, characterized in that the hard crystalline material (48) consists of polycrystalline diamond (PCD).

6. Device according to Claim 1, characterized in

that the hard crystalline material (48) consists of cubic boron nitride (CBN).

7. Device according to Claim 1, characterized in that the angle (ß) is between 10° and 50°, preferably between 15° and 30°.

8. Device according to Claim 3, characterized in that the parent body (32) forms an elongated, flat cutter tip (31) which can be fastened to a drilling head of a reamer, the secondary cutting edge (54) being arranged on a longitudinal side (37) of the cutter tip (31).

9. Device according to Claim 3, characterized in that the parent body is formed in one piece by the drilling head (61) of a reamer, the secondary cutting edge (68) being orientated at least approximately parallel to the drill axis (67).

10. A cutting tool having a main cutting edge and a secondary cutting edge inclined thereto, said cutting tool comprising a body portion, a relatively harder tip secured to said body portion and a backing portion disposed between said tip and body portion and having a hardness intermediate the hardness of said body portion and tip, the arrangement being such that said main cutting edge is provided by said tip and said secondary cutting edge is provided successively by said tip, backing portion and body portion.

11. A cutting tool substantially as hereinbefore described with reference to Figures 1 and 3 to 6 and Figures 7 and 8.

12

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The arch report)

Application number
GB 9424105.6

Relevant Technical Fields

(i) UK Cl (Ed.N) B3B, B3C, B3K

(ii) Int Cl (Ed.6) B23B, B23D

Search Examiner
V L C PHILLIPS

Date of completion of Search
31 JANUARY 1995

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE DATABASES: WPI

Documents considered relevant following a search in respect of Claims :-
1-9 and 11

Categories of documents

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Category	Identity of document and relevant passages	Relevant to claim(s)
	NONE	

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